INTERMOUNTAIN STATION
Central Reference File
No. 0.73 X 2.271

APPLIED FORESTRY NOTES

NORTHERN ROCKY MOUNTAIN
FOREST AND RANGE EXPERIMENT STATION

No. 90 Missoula, Montana May 1939

DIRECT SEEDING IN THE WESTERN WHITE PINE TYPE

By

C. S. Schopmeyer

Current direct seeding studies on coniferous species in the western white pine type have produced some very encouraging results particularly in view of the fact that previous attempts at direct seeding have generally failed. The failures in the older trials probably were caused by lack of protection from the depredations of rodents, such as chipmunks and field mice, and to unfavorable site conditions. The success of the current studies is attributed to the use of adequate protection of seed spots against rodents and to the selection of more favorable sites.

Four latin square plots were sown in the fall of 1937 and four more in the spring of 1938. These plots are located in the Kalispell Creek drainage in the Kaniksu National Forest (Pend Oreille County, Washington) and in the drainage of the North Fork of the Coeur d'Alene River in the Coeur d'Alene National Forest (Kootenai County, Idaho). Both areas were clear cut and broadcast burned previous to the time of sowing. Comparisons of germination, survival, and degree of stocking were made between ponderosa pine, western white pine, and Engelmann spruce; between spring and fall sowing; and between spots protected from rodents with conical screens and unprotected spots. The type of screens used in these tests is shown in figure 1.

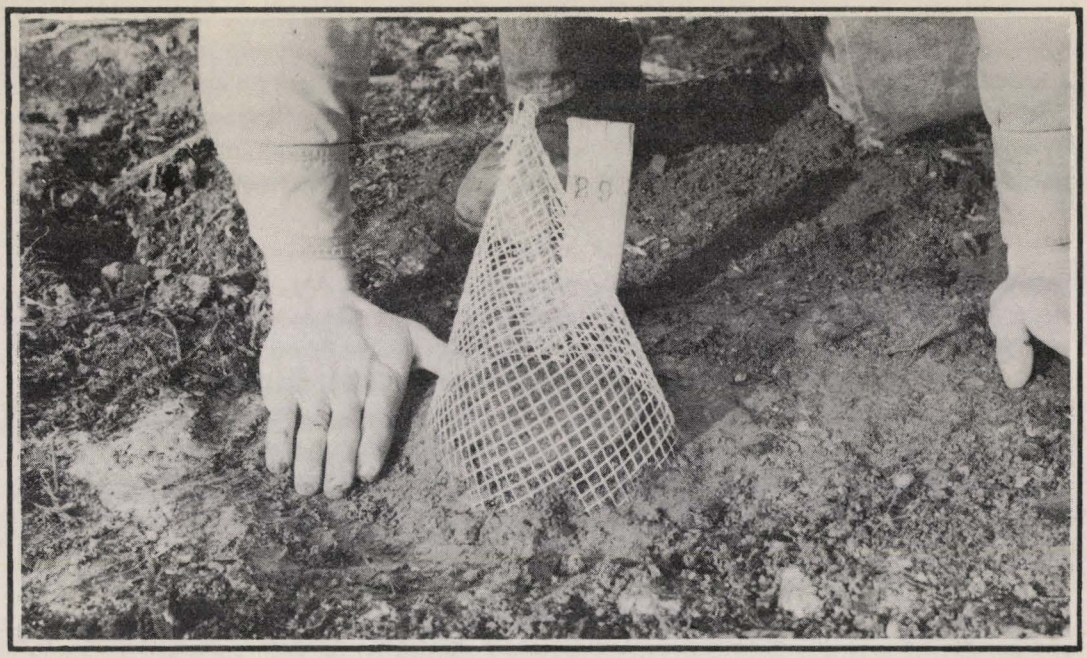


Figure 1.--Seed spot protected with conical screen.

Two fundamental requirements of a practical seeding operation are, first, that a sufficient number of seeds germinate to give rise to a fully stocked stand of timber and, second, that seedling mortality be sufficiently low to permit the development of a fully stocked stand. To show how closely the various treatments used in this study satisfy these requirements, data on germination, mortality, and degree of stocking are presented in table 1.

The season of sowing, the presence or absence of protection from rodents, and the size of seed each had a great influence on germination. Fall sowing of seed of all species resulted in an average germination of over 60 percent, as shown by the curves in figure 2, while germination of spring-sown seed was not more than 25 percent of the number of seeds sown for any of the three species. Low germination of spring-sown seed is attributed to unfavorable soil moisture conditions following spring sowing. The extremely low germination of less than 5 percent for spring-sown seed of western white pine was probably caused by the failure of the stratification treatment used on the seed of this species to complete the necessary after-ripening processes. These germination percentages, which were determined in field tests under screened enclosures outside of the plots, do not agree with the average numbers of seeds germinated per spot shown in table 1.

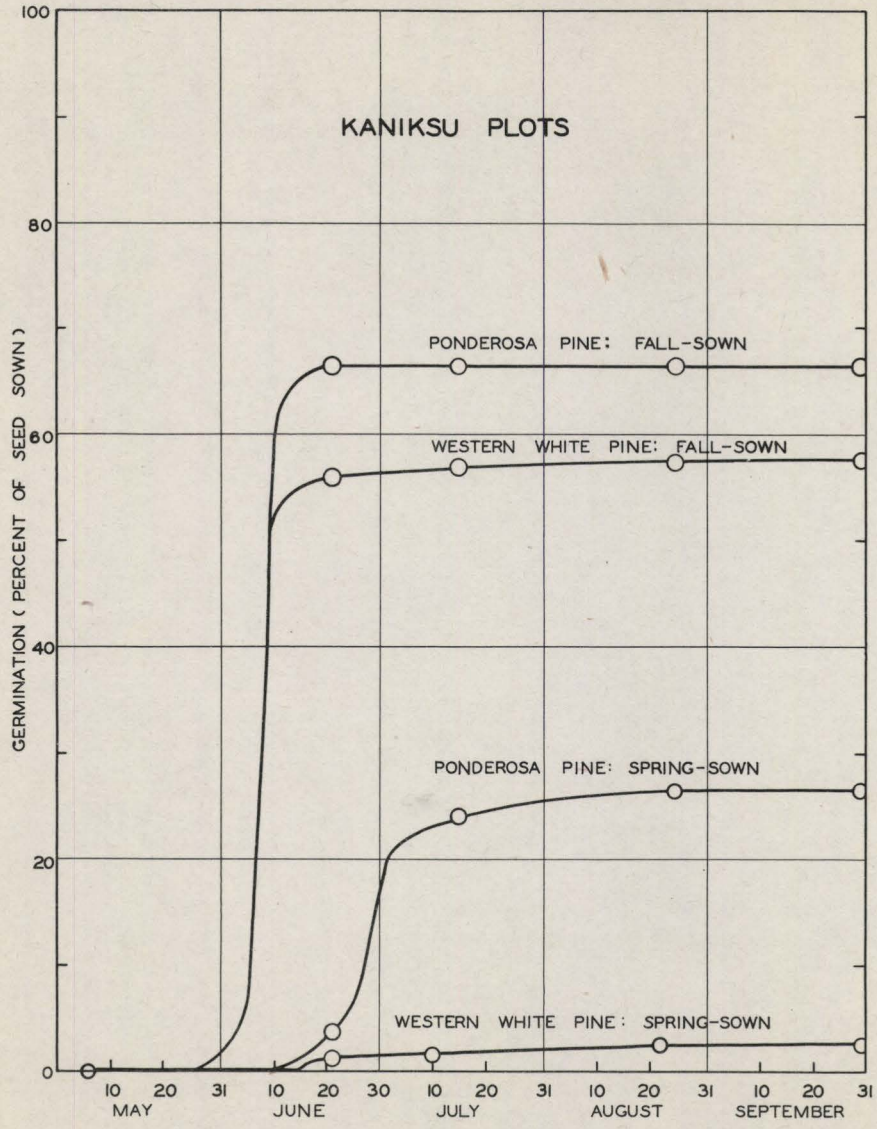
Table 1.--Germination, mortality, and degree of stocking in direct-seeding plots.[1/]

Location of plots	Species	Germination				Mortality[2/]		Stocked spots[3/]			
		Screened spots		Unscreened spots		Screened spots		Screened spots		Unscreened spots	
		Fall sown	Spring sown	Fall sown	Spring sown	Fall sown	Spring sown	Fall sown	Spring sown	Fall sown	Spring sown
		Average number of seeds germinated per spot				Percent of germination		Percent of total spots			
Kaniksu National Forest	Ponderosa pine	24.4	5.6	0.5	0.2	5.4	19.0	100	65	25	10
	Western white pine	9.8	1.5	0.4	0.1	19.4	35.2	85	32	18	1
Coeur d'Alene National Forest	Western white pine	28.8	4.4	1.0	0.4	14.1	10.2	91	20	39	20
	Engelmann spruce	25.8	25.3	7.6	8.4	21.9	25.7	96	67	84	67
Average for all species		22.2	9.2	2.4	2.3	15.2	22.5	93	46	42	24

1/ Each figure on fall-sown seed is based on 288 spots; each figure on spring-sown seed is based on 192 spots.

2/ Mortality for unscreened spots was omitted because of insufficient numbers of seedlings on which to base percentages.

3/ Number of spots having one or more seedlings at end of first growing season expressed as a percentage of the total number of spots sown.



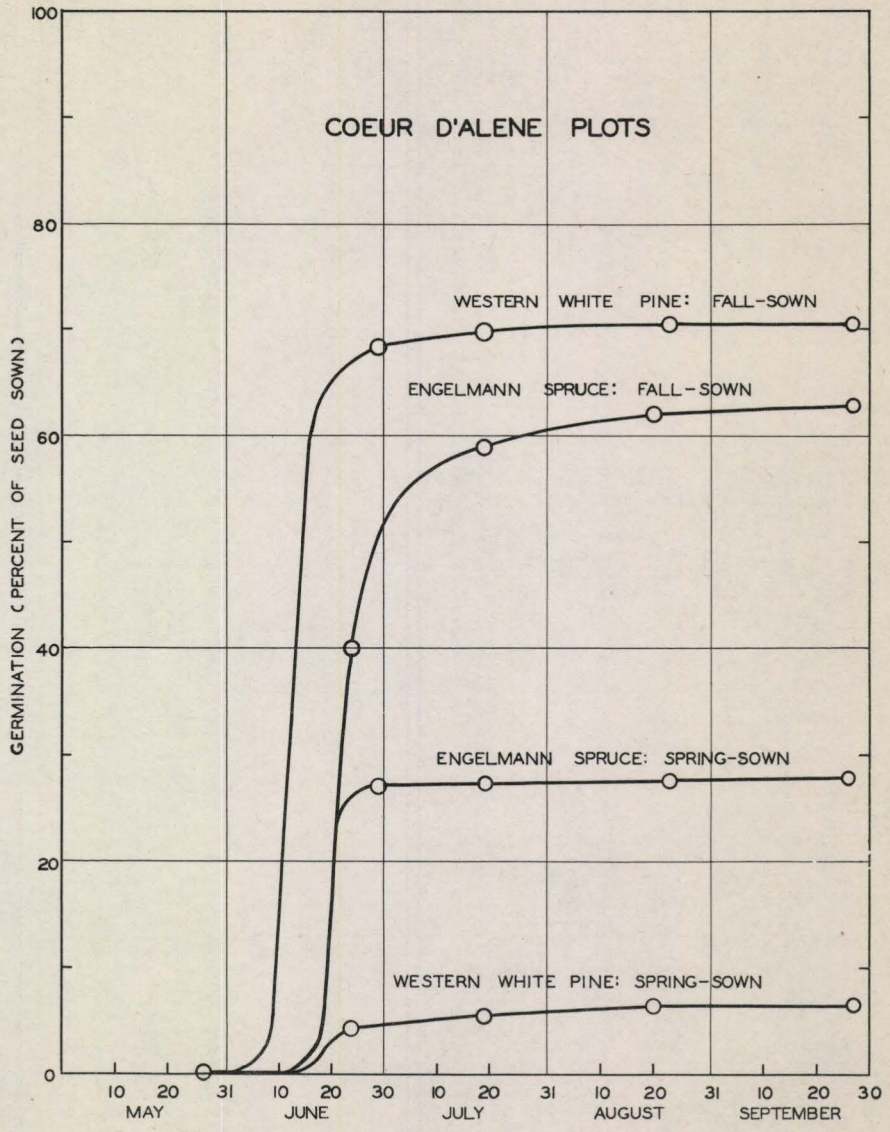


FIGURE 2. GERMINATION DURING THE 1938 GROWING SEASON IN DIRECT-SEEDING PLOTS ON THE KANIKSU AND COEUR D'ALENE NATIONAL FORESTS.

The inconsistency was probably caused by the fact that the number of seeds sown in each spot was not counted and hence was not the same in all spots, while in the germination test an accurate count was made of the number of seeds sown and the number germinated. Among the screened spots within the plots, fall sowing, which resulted in an average of 22 germinated seeds per spot, was much better than spring sowing which resulted in only 9.2 germinated seeds per spot. In the unscreened spots, rodent depredation was the limiting factor in germination; hence, the effect of season of sowing is not so apparent. Germinated seeds in unscreened spots sown with western white pine and ponderosa pine averaged less than one per spot in both the spring- and fall-sown plots. Destruction of seed by rodents undoubtedly caused this low germination because practically every unscreened spot showed evidence of rodent digging within 2 days after sowing. Unscreened spots sown with Engelmann spruce seed, however, had an average of 8 germinated seeds per spot in both the spring- and fall-sown plots. Apparently the small size of the seeds of this species made them less attractive to rodents.

First-year mortality, being only 19 percent of the number of seeds germinated in screened spots, was not a serious threat to the development of seedlings. No mortality percentages were calculated for seedlings in unscreened spots because of insufficient numbers of seedlings. Mortality in screened spots was less than half of that for either natural reproduction or planted trees. Average first-year mortality for natural reproduction on cutover areas over a period of 7 years (1927-34) was 43 percent for native species of the western white pine type. Average first-year mortality on all plantations in western Montana, northern Idaho, and northeastern Washington over a period of 26 years was 42 percent. Although a mortality percentage determined from the results of only one season cannot be used for predicting average expected mortality, the mortality observed in this study is indicative of what might be attained on selected seeding sites.

The number of seedlings killed by damping-off fungi, drought and insolation combined, and cutting by biotic agents was determined by inspection for four periods during the growing season. The percentages of seedlings killed by each of these three causes are shown in figure 3 for each of the four periods. Damping-off fungi were active on the Kaniksu plots only during May and June, while on the Coeur d'Alene plots activity continued during July. The early drying of the sandy surface soil on the flat sites on the Kaniksu plots may have inhibited the growth of the fungi sooner than on the Coeur d'Alene plots which were located on north-facing slopes. The cutting agents were active all through the growing season but were most active during

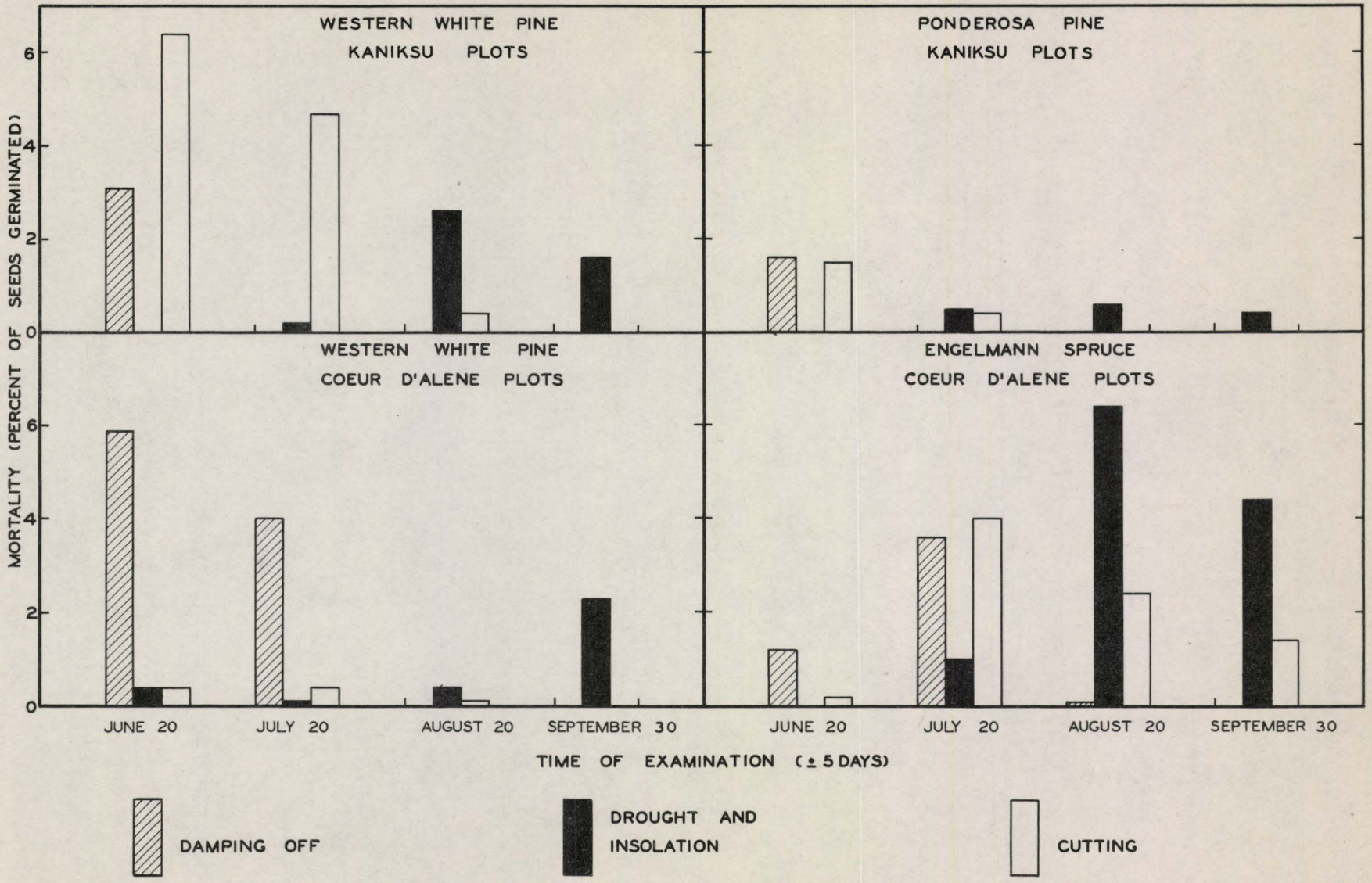


FIGURE 3. MORTALITY RESULTING FROM DAMPING-OFF, DROUGHT AND INSOLATION, AND CUTTING AT THE TIME OF EACH EXAMINATION DURING THE FIRST GROWING SEASON. PERCENTAGES ARE CIVEN ONLY FOR SCREENED SPOTS ON FALL-SOWN PLOTS

June and July. Losses from drought and insolation were first observed in July but did not become appreciable until August and September.

Analyses of the total mortality data summarized in table 1 show four interesting points.

1. The causes of mortality in the decreasing order of their destructiveness were cutting, drought and insolation combined, and damping-off.

2. Losses caused by damping-off were approximately the same for all three of the species studied.

3. Losses caused by drought and insolation combined were greatest in Engelmann spruce, intermediate in western white pine, and least in ponderosa pine.

4. Losses caused by cutting were greatest in Engelmann spruce, intermediate in western white pine, and least in ponderosa pine.

Cutting, the major cause of the losses observed in this study, was done in several different ways. Some seedlings were cut off at the ground line, others were cut off an inch or more above the ground line, and on a few the apical growth was cut off flush with the cotyledons leaving the latter intact. A number of different biotic agents seem to have participated in the cutting but none were identified. Since all forms of cutting were observed in screened spots as well as in unscreened spots, the damage apparently was not done by grazing animals.

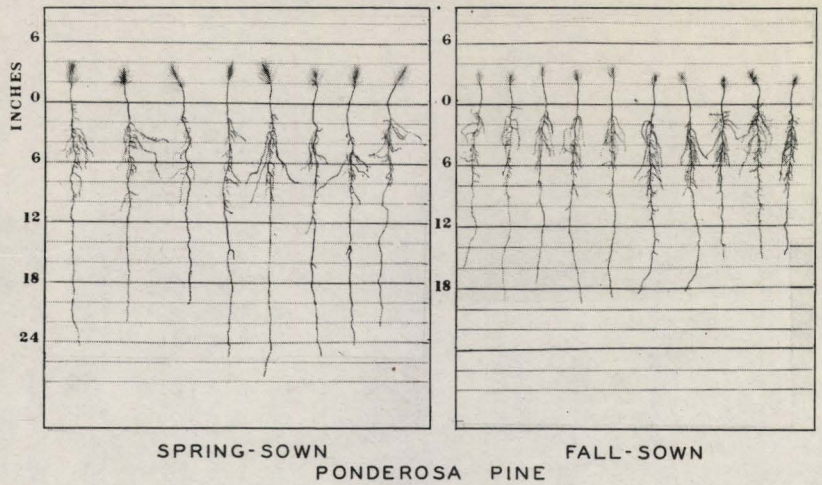
Drought and insolation losses seem to be correlated inversely with the relative depths of root penetration of the various species of seedlings. The total mortality percentages caused by drought after fall sowing in screened spots are 1.5 for ponderosa pine, 3.8 for western white pine, and 12.4 for Engelmann spruce while the average depths of root penetration for these species, as shown in table 2, are 15.5, 9.6, and 5.9 inches, respectively, for seedlings grown from fall-sown seed in screened spots. This inverse correlation can be explained readily on an ecological basis. As the summer drought progresses, the level of available water in the soil is gradually lowered. Hence, a seedling which can put down a long tap root may be able to absorb sufficient water to survive while the level of available water may go beyond the reach of a seedling with a shorter tap root.

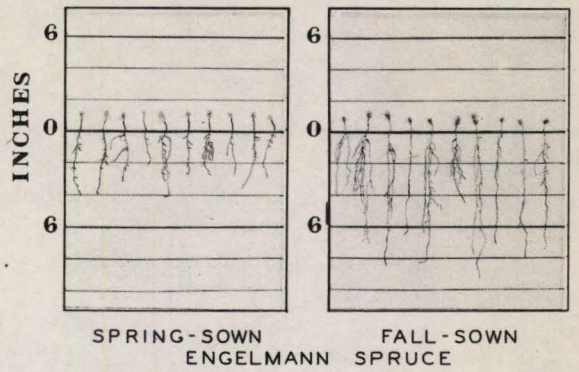
Table 2.--Average lengths of roots and tops of all seedings excavated on direct-seeding plots at end of first growing season in field.

Species	Season of sowing or planting	Number measured	Length of roots	Length of tops
			Inches	Inches
Ponderosa pine	spring	33	18.0	2.9
	fall	60	15.5	3.6
Western white pine	spring	67	8.5	1.8
	fall	109	9.6	2.2
Western white pine 2-2-1 planted stock 1/	spring	5	14.3	8.5
Engelmann spruce	spring	58	4.2	1.1
	fall	55	5.9	1.2

1/ Two years in seed bed, two years in transplant bed, and one year in field.

The later start in germination and growth resulting from spring sowing as compared to fall sowing seems to affect the depth of root penetration. Table 2 shows that root penetration of seedlings of western white pine and Engelmann spruce was 1.1 and 1.7 inches greater when grown from fall-sown seed than when grown from spring-sown seed. Ponderosa pine, however, made 2.5 inches more root penetration when sown in the spring than when sown in the fall. Figure 4 shows these differences in root penetration and also differences in root habit far better than they could be described in words. Each group of seedlings in this figure were excavated from a single spot, with the exception of the white pine planting stock, and do not represent all of the individuals measured to get the averages shown in table 2. The western white pine nursery stock shown in figure 4 was planted on the site of one of the Coeur d'Alene seeding plots at the same time the spring sowing was done. The average net root penetration of this stock, which was root-pruned to 8 inches before planting, was only 6.3 inches while white pine seedlings grown from spring-sown seed made an initial root penetration of 8.5 inches during the first growing season. Seedlings of ponderosa pine, however, with a root penetration of 18 inches when grown from spring-sown seed and 15.5 inches when grown from fall-sown seed, appear to be much better adapted for survival on dry sites than either nursery stock or field-grown seedlings of western white pine. The relatively shallow root penetration of Engelmann spruce seedlings, only 5.9 inches,





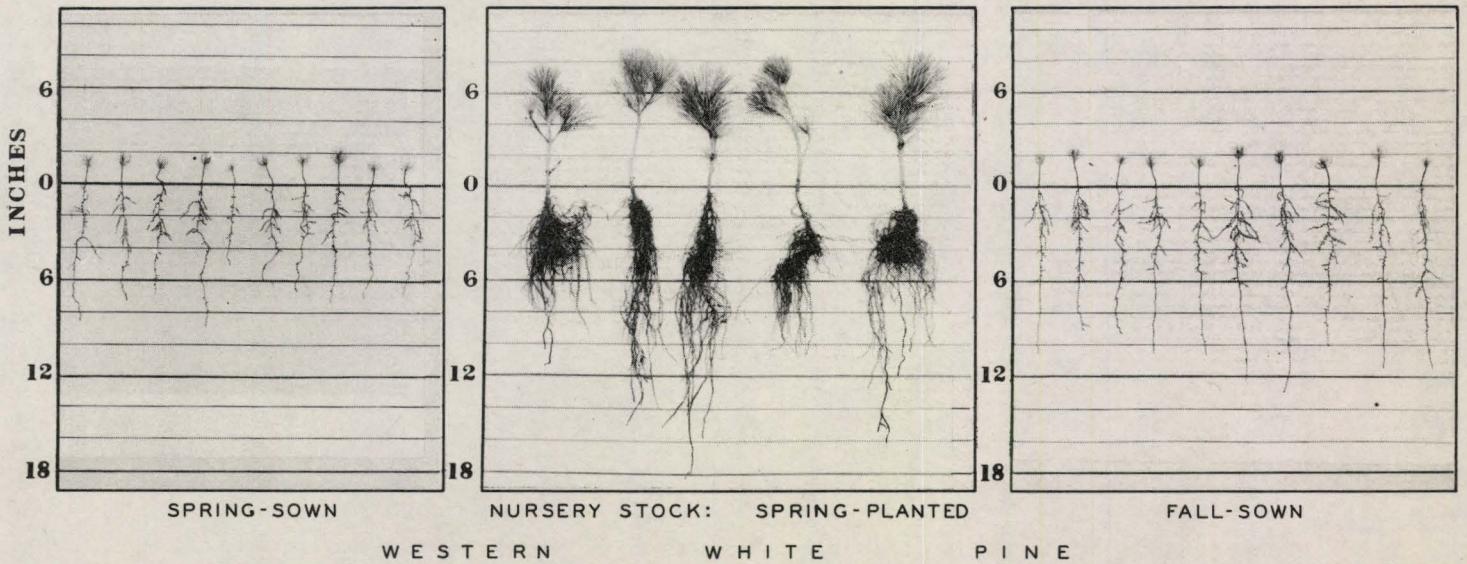


FIG. 4. SEEDLINGS GROWN FROM SPRING- AND FALL-SOWN SEED ON DIRECT SEEDING PLOTS AND 4-YEAR-OLD (2-2) WESTERN WHITE PINE NURSERY STOCK ROOT-PRUNED TO 8 INCHES BEFORE PLANTING. ALL PLANTS EXCAVATED AFTER FIRST GROWING SEASON IN FIELD.

shows that direct seeding of this species must be limited to the more moist sites where available soil moisture is maintained within reach of the short root systems.

The final criterion of the success to date of the seeding experiments is the percentage of spots with one or more live seedlings at the end of the first growing season. As shown in table 1 for all species, an average of 93 percent of the screened fall-sown spots had one or more live seedlings at the end of the first growing season. This percentage is very high compared to average stocking in plantations 1 year after planting. Stocking among the spring-sown screened spots, averaging only 46 percent, was much less satisfactory. The only species showing a reasonably satisfactory degree of stocking in unscreened spots was Engelmann spruce with one or more seedlings in 84 percent of the fall-sown spots and in 67 percent of the spring-sown spots. Screening apparently had no effect on the stocking among spring-sown spots, and among fall-sown spots stocking was only 12 percent greater in the screened spots. With the larger seeded species, western white pine and ponderosa pine, screening made a much larger difference in the stocking, being 3 to 5 times greater in the screened spots. The greater difference is probably caused by the greater attractiveness of the larger seeds to rodents.

The favorable results of these experiments cannot be attributed to favorable weather during the growing season. Weather Bureau reports show that the mean monthly temperature was higher than normal and precipitation less than normal for the 4-month period, June to September 1938, inclusive, in North Idaho. Hence, the summer drought was more severe than usual.

The results of these experiments show that direct seeding of large-seeded species such as western white pine and ponderosa pine can be done successfully if adequate protection from rodents is provided. On very favorable sites, small-seeded species such as Engelmann spruce can be seeded successfully without protection.

To make direct seeding economical, a cheaper means of protection than screening must be devised. Studies are now in progress at this station to develop economical methods for using poisons for rodent control on sites sown with large-seeded species. Further studies of the small-seeded species, Engelmann spruce and western red cedar, are also under way. If economical direct-seeding methods can be devised for use in this region, they will be a valuable supplement to planting.